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THE STUDY OF
TIMBER AND FOREST PRODUCTS
IN AMERICA

A Report presented to the Forestry Committee
of the University of Cambridge

by

E. R. BURDON, M.A.

Cambridge:
at the University Press
1912

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REPORT

on a visit to the United States and Canada for
the purpose of studying the Research Work
and Educational Methods of the Forestry
Departments and Forestry Schools in those
countries in connection with the study of
Timber and other Forest Products

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INTRODUCTION

THE following Report of Mr Burdon's visit to North America is published at the request of the Forestry Committee, University of Cambridge.

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Object of the Visit

The object of the journey, which was undertaken in accordance with a resolution of the Forestry Committee of the University of Cambridge, was to study the methods of research into the structure, properties and utilisation of timber employed in the United States and Canada, and the nature of the training given to Forestry students in this branch of the subject.

Route

On arrival at New York I at once proceeded to Washington, D.C. and obtained full information from the Head Office of the Forest Service Department as to the institutions it was advisable to visit. Acting on the advice received I visited the following :

Chicago, Ill.	Office of Wood Utilisation.		
Madison, Wis.	Forest Products Laboratory.		
Ann Arbor, Mich.	University of Michigan Forestry School.		
Toronto	University of Toronto	"	"
Cambridge, Mass.	Harvard University	"	"
Newhaven, Conn.	Yale University	"	"

PRODUCTS BRANCH OF THE UNITED STATES FOREST SERVICE

General objects and effects

The most important research work on timber in the United States is that which is being carried on by the Branch of Products of the Forest Service.

The main object of this branch is to develop more economical methods of utilising forest products generally, so as to eliminate the enormous waste which occurs not only in logging, but also in conversion into lumber and in manufacture.

In pursuance of this object the Products Branch endeavours to organise systematic scientific research and to disseminate information regarding the mechanical, physical and chemical properties of commercial woods and their products, the utilisation of forest products, the natural and artificial seasoning of wood, wood preservation, wood distillation, the production of paper pulp, naval stores and other chemical products. It also compiles statistics of production, consumption, prices and market conditions, investigates commercial methods of manufacture, of grading, and utilisation, and the possibilities of substitution of new species or other materials for woods which are becoming scarce, etc., etc. The range of the investigations of the Products Branch covers every industry which is in any way dependent on the forest for its raw material. The work is thus of the greatest economic value, and the results already obtained are doing more than almost any other agency to educate the timber trade at large to a proper appreciation of scientific forestry.

Organisation of the Branch of Products

The work of the Products Branch was formerly carried on at various stations and laboratories in the United States, viz. Washington, D.C., St Louis, University of California, Yale and other centres. This work has now been concentrated at Madison, and the organisation of the Branch is as follows:

- (a) The Forest Products Laboratory at Madison,
- (b) The Office of Wood Utilisation at Chicago,

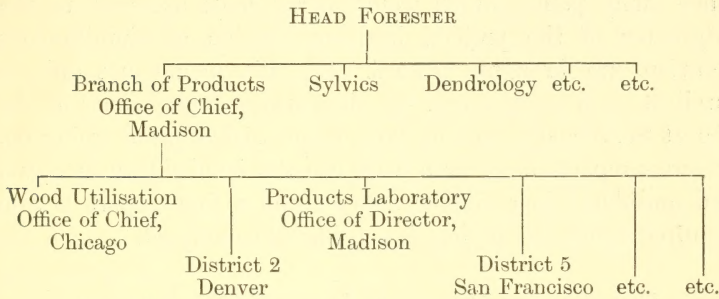
both co-ordinated under the direction of the Chief of the Branch who reports direct to Washington, D.C. A representative of the Branch in the Head Office of the Forest Service at Washington enables the Chiefs of other departments there to keep in close touch with the projects proposed for investigation and with the general progress of the research work.

The Chief of the Branch at present is also Director of the Products Laboratory at Madison.

In addition to this the whole country is divided up into districts, and an officer of the Products Branch is stationed at a

central point in each district, in order to enable the Branch to keep in close touch with the principal timber associations and wood-using industries of each district.

The general organisation is shown in the following diagram.



Organisation of the Work of the Branch of Products

This is divided between Chicago and Madison as follows:

Problems requiring experimental research by laboratory methods are dealt with at the Laboratory at Madison.

Problems capable of solution merely by co-operating with lumbermen or manufacturers are referred to the Chicago Office. This Office also serves as a public bureau for the collection and publication of information and statistics on the production, consumption, prices, etc., of all forest products.

Method of Procedure

Before commencement of any research project, a working plan as complete in detail as possible is insisted on. This working plan is submitted by the Head of the Department concerned to a Committee composed of all the heads of departments in the Products Branch. The need for the investigation, the present knowledge of the subject, the proposed method of procedure, with plans of any instruments required, the probable cost, etc., etc., are all laid before the Committee. The project after full discussion and criticism is revised and finally passed on by the Chief of the Branch for

similar consideration by a Committee composed of the Heads of the Forest Service Departments at Washington, D.C.

Although this occasions some delay in beginning the work, the method has been found to be most satisfactory, since many points which would never have occurred to the originator of the project, but are capable of simultaneous solution, are brought forward. By this means not only is duplication of work saved, but the various departments of the Forest Service are kept in close touch with what is going on. Progress reports of research work are also handed in at intervals and considered in a similar manner and a final report is also required before the project is considered completed.

THE FOREST PRODUCTS LABORATORY, MADISON
Selection of Madison and co-operation of Wisconsin
University

The Laboratory at Madison was opened in 1910, and, as mentioned above, the research work of the Products Branch was thereupon concentrated at this point.

The establishment of the laboratory at Madison was only rendered possible by the co-operation of the University of Wisconsin with the Forest Service. On the refusal of Congress to grant an appropriation to build a laboratory, various State Universities were invited to co-operate with the Forest Service in its establishment, and there was considerable rivalry between the Universities, especially those of Minnesota, Wisconsin and Michigan, for the institution. The liberality of the terms offered by the University of Wisconsin secured its establishment at Madison. The conditions were that in return for the provision by the University of the ground, and building, together with heat, light and motive power free of charge, the Forest Service should furnish the Staff, equipment and running expenses of the laboratory, and that members of the Staff should deliver courses of lectures to the undergraduates on the commercial uses of timber and other forest products.

This liberal offer of co-operation, coupled with the facts that Wisconsin is an important lumber- and pulp-producing State

and possesses an efficient State Forest Service free from political control, resulted in the selection of Madison for the location of the new Products Laboratory. The decision was also influenced by the high status of Wisconsin University, whose President, Mr Van Hise, is one of the most prominent advocates of Conservation of Natural Resources. In no other State has the University laid itself out so thoroughly to serve the needs of the people by organising research and disseminating knowledge useful in their daily lives. The authoritative status of the University in all agricultural questions, and the high degree of confidence reposed in it by the public, make it especially suitable as a centre for the work of the Forest Products Branch.

A similar confidence in the work of the Forest Products Laboratory is beginning to manifest itself, as was evidenced by the interest shown by one or two wood-using industries, which I visited, in certain experiments on artificial seasoning and wood preservation now in progress. Further evidence of this lies in the co-operation of the railroads who furnish free carriage for the supplies of the Laboratory, and of various lumber concerns and wood-using industries who provide material for experimental work free of charge.

General Description of Building and Grounds

The Products Laboratory is a substantial building of brick, stone and concrete, simple in design and eminently practical, situated on the outskirts of the town but within a few minutes' walk of University Hill on which most of the University Buildings stand.

The main building, which measures 182 ft. \times 90 ft., is fire-proof, contains two stories, and the roof space is used as an attic for storage. The cost to the University was about \$55,000.

Adjoining the building is an ample storage-yard of about 2 acres in extent. The property faces on to one of the main roads into Madison, and the track of the Chicago, Milwaukee and St Paul Railway, which crosses the road obliquely at this point, forms the boundary line on one side of the yard. A

switch line from the railroad has been laid into the yard so that the Laboratory possesses every facility for delivery and dispatch of material, and the handling of specimens by carters and railway men is avoided. Trucks can be run by a branch switch line to the saw-mill, or direct to the back of the main building, or unloaded at any point in the yard by means of a derrick.

Saw-mill and Drying Sheds

In the yard at the back of the main building, but separated from it by the switch line, stands a row of sheds, one end of which contains the saw-mill, while the other end is apportioned for seasoning experiments.

The saw-mill is equipped with one large circular saw with travelling log carriage and one small circular saw with table for trimming ends, etc.

The drying sheds are arranged so that seasoning may be carried on either by natural air-drying but protected from weather, or in closed sheds where the temperature and moisture conditions can be separately controlled.

Departmental Organisation of the Laboratory

The Products Laboratory is organised into eight technical sections for experimental research, and one non-technical section which attends to general maintenance.

The technical sections are as follows:

- (1) Timber-testing,
- (2) Timber Physics,
- (3) Wood Preservation,
- (4) Wood Distillation,
- (5) Pulp and Paper,
- (6) Engineering (with Drafting Room),
- (7) Chemistry,
- (8) Pathology.

The first five sections, which require heavy plant for their experimental work, occupy the whole of the ground floor, and

there is also a wood-working shop on this floor. The last three sections are placed on the upper floor, the remainder of which is apportioned to offices, private rooms, library, photographic dark room, etc.

Staff

The Staff of the Laboratory, which is entirely provided by the Forest Service, numbers about 55 men of whom some 33 are technically trained men recruited from the professions of Forestry, Engineering and Chemistry. Of these the Engineers are in the majority, but all have some knowledge of Forestry. The remainder of the Staff are chiefly engaged as clerks, stenographers, carpenters, etc.

Wood-working Shop

This is a carpenter's shop furnished with various machines for sawing, shaping and dressing wood to the required sizes for experimental work. The shop opens conveniently into the timber-testing laboratory on one side, into the wood-preservation laboratory on the other, and into the yard at the back. The equipment includes Circular and Band Saws suitable for different classes of work, a short log saw-mill and edger, machines for trimming, edging, planing and mortising, wood-turning lathe, work-bench, etc.

(1) Timber-testing Department

Here investigations are made into the mechanical properties of wood both before and after manufacture, or preservative treatment, or seasoning.

At present tests are being carried out on the different commercial woods of the United States with a view to determining their relative mechanical properties, e.g. strength, toughness, hardness, etc. A point wherein these tests differ from those generally made by engineers is that the specimens are collected from the forest, and the history of each, the conditions of soil and environment, etc., under which each was grown, are known. The structure of each specimen is noted from microscopic sections made in another department, and as

sufficient data accumulate attempts will be made to correlate the structure with the mechanical and physical properties. It is hoped that this work may in time enable each species to be so graded according to structure and corresponding strength, that the factor of safety rendered necessary by the tables at present used by engineers, architects, etc., may be materially reduced. If by any means it is found possible to do this in such a manner that, by examination of the structure, an engineer may at once know within moderate limits the strength of a log, the work will be of immense value. But even apart from this the work will be of service by enabling consumers to readily find substitutes for woods which are becoming scarce.

Other tests are being made in this section to determine the effect which the treatment of wood under pressure in the process of preserving has on its mechanical properties.

The effects of different methods of seasoning on the mechanical properties are also investigated.

The equipment of this Laboratory consists of

one 200,000 lbs. Riehlé testing Machine ;

one 100,000 lbs. Olsen " "

three 30,000 lbs. Olsen " "

one 60,000 inch pound Riehlé torsion testing Machine ;

one impact testing Machine ; and various machines for doing shop-repairs, grinding tools, etc.

Another apparatus, which is best described under this section though it is actually set up in the Timber Physics Laboratory, is one which has been specially designed for determining the effect of dead loads on beams, the deflections of each beam being automatically recorded upon a revolving drum. The object of this research is to ascertain the relations that exist between the strength of a material as demonstrated by ordinary testing machines working at uniform speed, and its strength when placed under a constant stress or dead load.

(2) *Timber Physics Department*

In this section studies are made of the physical properties of wood and their relation to structure. These include

determination of the specific gravity, specific heat, the effects of changes of temperature, pressure and moisture on the wood substance and general structure, etc. These researches have a special bearing on the artificial treatment of wood in the processes of seasoning, fire-proofing, preserving under pressure, etc., when it is important to know the effect of different pressures, the amount of heat required, the length of time different kinds of wood may be exposed to certain conditions and so forth. The results of this work therefore serve as a valuable check on the experiments of other departments.

The main equipment of this Laboratory consists of a very complicated apparatus which was specially designed for studying the problems connected with the artificial seasoning of wood. This consists of a jacketed cylinder in which the wood to be examined is placed. The cylinder and the jacket are separately connected up to a vacuum-oven, a carbon-dioxide-generator, an air-compressor and to two boilers in such a way that the temperature, moisture, pressure and gaseous contents of the cylinder can all be separately controlled. With this apparatus it is possible to study the influence of variation of one factor while the others remain constant, and a wide range of conditions in seasoning can thus be controlled.

The experimental Dry Kiln in the yard behind the building enables theories deduced in the course of these experiments to be put to the practical test on a small scale.

The experiments in this Laboratory are being followed by many manufacturers with considerable interest. The head of a furniture factory in Chicago informed me that he was waiting for the publication of further results before deciding on the type of a new Drying Kiln he wished to instal.

The Pioneer Pole and Shaft Co. at Cairo, Illinois, got the department to superintend the installation of a dry kiln at its factory.

The Vehicle Makers' Association have requested the Laboratory to find out a quick process for seasoning hickory in order to minimise the damage done by boring insects during the lengthy process of seasoning which at present seems necessary.

Microscopy and Photomicrographs

This department also possesses a complete equipment for preparing sections and photomicrographs of wood. The collection of these, which I spent considerable time in examining, showed work of the highest quality. The Microtome generally used was made by Jung (Model Th. No. 51) in which the object is fixed and the knife moves on a carriage. The Bausch and Lomb Microtome in which the object moves against a fixed knife is rarely used. The apparatus for Photomicrography is one made by Bausch and Lomb, and the photographs in the general collection are all taken to the same magnification, ($\times 50$), which is sufficient to show the most important details of the cell-wall structure. The chief use of these sections is in the study of the minute physical structure in its relation to physical and mechanical properties, and the effect on the structure of artificial treatment in preserving or seasoning, etc.

Specimens of pulp are also examined microscopically and photographed to assist in determining the value of the fibre in paper making.

The collection when more complete will also be used for the construction of a key to the identification of American woods based on structure.

Collection of Wood Specimens

There is no Museum for exhibition purposes attached to the Products Laboratory, but a collection of North American woods is being made by this department. The specimens are in the form of half-logs 4 ft. long, with bark attached, cut so as to display the transverse, radial, tangential and obliquely tangential surfaces.

(3) *Wood Preservation* and (8) *Pathology Departments*

The wood of these two departments is so closely connected that it is simpler to describe them together. The Wood Preservation Laboratory contains a very complete equipment

for testing the various problems of wood preservation by treating the wood with materials which increase its durability.

These problems may be divided broadly into two classes :

- (a) Those dealing with the preservatives themselves, their effect on the wood and their efficiency in resisting fungi, insects and fire.
- (b) Those concerned with the methods of forcing the preservative into the wood.

(a) In the study of the first of these problems the preservatives are analysed and fractionally distilled in the chemical laboratory. The efficiency of each preservative and its different fractions is then tested by subjecting woods treated with them to the action of wood-destroying fungi or animals, and noting their relative powers of resistance. The effects of weather on the preservative in the treated specimens are also investigated and taken into account in judging efficiency.

In this work the Products Laboratory co-operates with the Pathological Department of the Bureau of Plant Industry and also with the Bureau of Entomology. A qualified Mycologist from the former Bureau has an office in the Forest Products Laboratory, and devotes the whole of his attention to the collection and study of wood-destroying fungi. Pure cultures of these are made and kept in stock in large jars, and the resistant power of the preservatives is tested by plunging treated specimens of wood into these jars.

The efficiency of each preservative or of its fractional distillates is also tested by making culture media of wood-destroying fungi to which the preservatives are added in different percentage strengths. The extent to which the fungus succeeds in growing in such media affords an indication of the efficiency of the preservative.

Experiments of a similar kind on a larger scale are also being attempted in a fungus pit which has been specially constructed below the floor in one corner of the Wood Preservation Laboratory. This pit contains large chambers in which the temperature and humidity can be regulated, and, when the conditions favourable to the growth of each particular

fungus have been ascertained, a culture of this fungus is grown in one of the chambers. Specimens treated with different preservatives are then introduced and inspected at intervals to ascertain the resistant properties of the preservative. Up to the present however the fungus pit has not worked very successfully, owing to difficulties in regulating the conditions necessary for each particular species of fungus.

(b) The equipment for studying the second class of problems, viz. the methods of impregnating the woods with the different preservatives, is very complete.

There are four sizes of pressure cylinders:

- one of 8" diam. \times 12"; maximum working pressure 300 lbs. per sq. in.,
- one of 12" diam. \times 24"; maximum working pressure 300 lbs. per sq. in.,
- one of 18" diam. \times 4 ft.; maximum working pressure 600 lbs. per sq. in.,
- one of 3½ ft. diam. \times 12 ft.; maximum working pressure 300 lbs. per sq. in.

This last cylinder is equipped with a travelling carriage for loading and can be utilised for experiments on a semi-commercial scale. These cylinders are connected up with a system of measuring tanks, and air-, vacuum- and force-pumps, so that all the factors in the process of treatment may be separately and exactly controlled. An open tank is also provided in which the effect of soaking specimens in preservatives without pressure, as well as the degree of penetration obtainable by alternating applications of hot and cold preservative, can be investigated. For the farmer class and others whose operations are not on a large enough scale to warrant the installation of a pressure plant, the knowledge gained from these open tank experiments will be of service. Another piece of apparatus is specially designed for observing the course which the preservative takes through the wood elements when injected under pressure.

Other problems, such as the loss of preservatives by evaporation at different temperatures, the relative inflam-

mability of woods, etc., are being investigated with the help of ingenious pieces of apparatus designed for each problem. With this equipment the Laboratory is enabled to put any theories which have been evolved through researches on a small scale to a practical test on a semi-commercial scale. In these larger experiments various commercial concerns gladly co-operate with the Laboratory, for the work is already proving of immense benefit to railroads, shipping and mining companies, municipal bodies (for street paving), telegraph and telephone companies, farmers, etc. At the present time railroad ties which have been treated in various ways in this Laboratory are in use on a reserved length of the track of the Chicago, Milwaukee and St Paul Railway.

Piles which have been treated to test the possibility of preserving them against marine boring animals have been sunk in the waters of the Gulf of Mexico and the Bay of San Francisco.

In many other parts of the United States there are test tracks, pole-lines, fence-lines, mining props and greenhouse timbers set out under actual service. The location of all these test timbers is kept on a map at the Products Laboratory, and they are inspected annually by members of the Staff who keep careful records of the condition of every piece.

(4) *Wood Distillation Department*

In this Laboratory studies are made of the products obtainable from different woods and the most economical methods of extraction. The equipment consists of one steam distillation and extraction retort, one oil jacketed destructive distillation retort, and stills for refining. The Department also conducts turpentine distilling operations on a semi-commercial scale in co-operation with a turpentine factory in Georgia where a fractionating column still has been set up for this purpose.

The work of this department is of high economic importance, for its main object is to find a profitable use for the enormous waste of material which occurs, not only in the forest in the

shape of tops, branches and stumps, but also in the saw-mills and factories, in the shape of slabs, ends, shavings and sawdust. The disposal of surplus sawdust over and above that used as fuel is a question which confronts mill-owners in every country who generally dispose of it in a refuse burner. Processes for converting it into ethyl alcohol (grain alcohol) or other substances have been attempted from time to time in different countries, but hitherto without enough success to warrant the general adoption by mill-owners. This question is being closely investigated by this Department, and designs for an experimental plant to produce ethyl alcohol from sawdust are now being drawn up.

Another line of investigation has been the commercial methods of collecting and refining turpentine, and the improved methods suggested are gradually being adopted by the trade. In this work the Department co-operates with the paint- and varnish-makers to see how far the uses of turpentine and pine-oil can be extended. The question of finding substitutes for the rapidly disappearing Long-leaf Pine as a source for the production of turpentine is also engaging attention.

(5) *Pulp and Paper Department*

The work here is mainly directed at present to the discovery of woods which can be substituted for Spruce as a source of pulp in view of the rapid disappearance of the Spruce forests. This involves studies of the methods by which ground wood pulp can be obtained from species other than Spruce; of the potentialities of different woods in the manufacture of chemical pulp; of the qualities of paper which can be made from various grades of sulphite, soda and ground wood pulp; and of the possibilities of utilising various forms of forest and mill waste for the manufacture of pulp.

A miniature pulp and paper mill has been installed consisting of two 30 lb. digesters, one for soda, the other for sulphite pulp, an acid making system, the necessary grinders, beaters and screens, and a Fourdrinier paper machine capable

of making a roll of paper 15 ins. wide. In addition a branch Laboratory, for which Congress gave a special appropriation of \$30,000, has been set up at Wausau, for the separate study of making ground wood pulp from woods other than Spruce. This Laboratory, which I did not visit, is equipped with a commercial grinding plant which is specially designed to allow of the speed of the grinder being varied through wide limits.

The work of both laboratories is carried on in closest co-operation with the paper manufacturers of Wisconsin and with the National Pulp and Paper Association. Meetings are held at frequent intervals, and samples of pulp and paper made in the Laboratory are submitted for examination, and the methods of preparation explained and discussed. If required the Laboratory is ready to prepare pulp by any method in sufficient quantity for the manufacturer to test it on a commercial scale.

(6) *Engineering Department*

The work of this section, apart from the care of the machinery in the yard and building, consists in the designing of plant and apparatus. The discovery of improved methods of working wood, or new applications for a given wood or wood product, is at once followed by designing apparatus which will enable the discovery to be put to commercial use. The diversity of apparatus which is designed in the drafting room may be judged by the following items:

An Experimental Dry Kiln.

A Hack for turpentineing trees which will give better results and do less damage than the one in general use.

A Machine for grinding woods of different texture to Spruce.

Fixed and portable plants for wood preservation.

(7) *Chemistry Department*

The work of this section is of course carried on in close collaboration with every other section.

The main problems engaging its attention at present are the analysis and grading of commercial creosotes to determine their value as preservatives, and the analysis and grading of turpentine and rosins.

OFFICE OF WOOD UTILISATION, CHICAGO

The main object here, as in the Products Laboratory, is to promote more economic utilisation of wood by elimination of waste in both forest and mill, but, as mentioned above, this Office only attempts the solution of problems which do not require the application of Laboratory methods and can be solved by direct co-operation with lumbermen and manufacturers.

To achieve this a thorough knowledge of the timber business generally is essential, and detailed studies are being made of the wood-using industries of each State. These studies include statistics of production and consumption of lumber, the kinds of wood used, the source whence obtained, the product manufactured from each kind, and a variety of information as to market conditions, prices, etc. The work is carried on in co-operation with manufacturers, who are invited to supply the necessary information, and in most cases the States also lend the assistance of their Boards of Forestry, of Agriculture, of Labour, of Statistics, etc. In the Reports published, the information is carefully summarized so as to prevent disclosure of any details which might be detrimental to a manufacturer's interests.

The natural hesitation about supplying data which manufacturers at first evinced is rapidly diminishing in view of the general utility of the information thus rendered available, and the Reports prove of great assistance not only to manufacturers, lumbermen and owners of wood-lots, but also to each State in the consideration of its forest policy.

As a result of the knowledge acquired by these studies, covering as they do every important home wood-using industry, the Office is enabled to co-operate still more closely with

manufacturers by giving valuable suggestions for the utilisation of material which would otherwise be regarded as waste. The waste of the larger industry is frequently capable of being made the raw material of the smaller factory, and an instance of this I saw in Palatka, Florida, where a small but flourishing Bucket and Keg Factory was practically living on the waste of a large saw-mill. Previously the bucket factory bought its own logs, while waste from the saw-mill went into the refuse burner. In another instance, by influencing co-operation between a saw-mill operating largely in Swamp Cypress and a manufacturer of tobacco boxes, the waste of the saw-mill was found suitable as the raw material of the box-maker.

The office is also ready to help manufacturers in the discovery of substitutes for species of trees which are becoming scarce. *Juniperus virginiana*, for example, of which cedar pencils are made, is a wood for which a substitute is urgently wanted. Owing to its growing scarcity, the Office of Wood Utilisation has supplied samples of likely substitutes from the national forests to four large pencil manufacturers who are trying the possibilities of the woods and are submitting pencils made from them to the Office for inspection.

In a similar way the Office is investigating woods suitable for the manufacture of weaving shuttles in place of Persimmon wood, supplies of which are limited. The National Hickory Association has requested the Office to undertake a study of the utilisation of Hickory with a view to improving the methods of manufacture. These illustrations show the range of work in this Office and the high degree of confidence reposed in the Forest Service by both lumbermen and manufacturers.

FORESTRY SCHOOLS

As mentioned at the beginning of this Report the Forestry Schools visited were those of Yale, Harvard, Michigan and Toronto Universities, which are recognised as being of the highest standard in North America. All of these are housed in temporary buildings which have been adapted for the purpose, and I was therefore unable to gain any ideas as to the most

suitable type of building for a Forestry School. None of them possesses a museum, nor is there even adequate accommodation for the collections of material necessary for class work.

Work on Timber in Forestry Schools

The most pressing needs of the United States and Canada in connection with Forestry at present lie in the better management of the woods and forests, and it is therefore natural to find that the work in their newly established Forestry Schools is almost entirely directed towards giving students a thorough training in the silvicultural side of Forestry.

The study of Timber Physics, under which term I include all such studies as are undertaken at the Forest Products Laboratory, occupies quite a secondary position in the curricula of Forestry Schools, and except for microscopical studies of timber structure, no other research work is carried on.

Each of the four Forestry Schools visited, viz. Yale, Harvard, Michigan and Toronto, is however well equipped with microtomes and apparatus for studying the microscopical structure of timber, and a good deal of valuable research work in this branch of the subject is being carried out, especially at Yale and Harvard.

It is realised that a thorough knowledge of timber structure is necessary for students to enable them not only to identify timbers but also to correlate the properties and uses of different woods with the structure peculiar to each. A full course of lectures with laboratory work is accordingly provided in each Forestry School for this side of the subject. The remainder of the ground is covered by short courses of lectures only, without any laboratory work in connection with them.

I was informed however by President Van Hise of Wisconsin University that this want in Forestry education is about to be filled by the establishment there of a Forestry School to be run on special lines. In this school, attention will be focussed on the Forest Products rather than on the Silvicultural side of Forestry, and the teaching will be based on the research work of the Products Laboratory Staff, who will co-operate with the University in this development.

A detailed statement of the courses on Timber Physics and wood technology given at the four Forestry Schools visited will be instructive for comparison with our procedure at Cambridge.

TORONTO.

One course on Timber Physics and Wood Technology.	
Lectures and Laboratory work	<u>75 hours</u>

MICHIGAN.

One course on Timber Physics and Wood Technology.	
Lectures and Laboratory work	<u>60 hours</u>

HARVARD.

One course on Wood Structure.	
Lectures and Laboratory work about	72 hours
One course on Forest Products and Timber Physics.	
Lectures only	48 "
	<u>120 hours</u>

YALE.

Junior Year	{	One course on Special Morphology of Woody Plants.	
		A preliminary study of selected types	66 hours
		One course on the Chemistry of Forest Products.	
		Lectures only	36 "
Senior Year	{	One course on the Classification and Structure of Woods.	
		Lectures and Laboratory work	72 "
		One course on the Mechanical Properties of Wood.	
		Lectures only	10 "
		One course on Wood preservation.	
		Lectures only	10 "
			<u>194 hours</u>

Acknowledgments

Before closing this report I wish to record my indebtedness to Dr H. S. Graves, the Head Forester, to Mr A. F. Potter, and to the many other members of the Forest Service whom I was privileged to meet at Washington, Chicago and Madison for the ready assistance which was rendered me during my tour. Every

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